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STUDIES OF SETTLEMENT AND SEEPAGE AT CLARK HILL DAM DURING AND AFTER CONSTRUCTION

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STUDIES OF SETTLEMENT AND SEEPAGE AT CLARK HILL DAM DURING AND AFTER CONSTRUCTION

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Clark Hill Dam is located on the Savannah River about 22 miles upstream from Augusta, Georgia. Its overall length is 5660 feet and its maximum height is 180 feet above the channel bed. The central portion consists of a concrete spillway and non-overflow section. Rolled earth embankments extend to the east and west and are, respectively, 1350 and 2050 feet long. These have a combined volume of about 3,000,000 cubic yards and reach a maximum height of 150 feet above the original ground.

The dam site is near the southeastern margin of the Piedmont plateau, and is underlain by granite gneiss and granite. Weathering has occurred in its upper portion and open joints and cleavage planes are present. On both abutments, the rock is overlain by residual soils formed by decomposition of the bedrock. In general, the upper portion consists of micaceous lean and sandy clay. The lower portion consists of unoxidized products of weathering and decomposition of the bedrock in various stages of alteration. Considerable amounts of finely divided mica are present. These foundation materials may be classified as micaceous silts, sandy silts and silty sands. The average depth of the overburden is about 30 feet, although in some locations it may be as deep as 50 feet. Across the flood plain, the overburden is alluvial and consists in general of erratic deposits of sands, silts and clays. Its average depth is about 20 feet. Near the base of the east abutment, this depth increases to about 60 feet. In this area, the foundation consists of a top stratum of impervious clays and silty clays underlain by lenses of sandy silts, silty sands, and some medium to fine sand. The impervious stratum extends to a depth of about 20 feet and its thickness increases slightly in the downstream direction.

The major portion of the fill materials were obtained from areas having the same general characteristics of the abutment foundations previously described. Properties of typical materials are shown in figure 1. It was found that the permeability characteristics of the lean clays and highly micaceous silty soils were comparable. The dam was designed as if it were homogenious in this respect. However, during construction, efforts were made to place the sandier soils near the outer section.

The slopes of the earth portion of the main dam average 1:3 upstream and 1:2-1/2 downstream. A cut-off trench was excavated to rock along the centerline for the entire length of the earth structure. The rock was curtain grouted to a depth of 50 feet. The cut-off trench was then backfilled with select impervious material. Except in the flood plain, no provisions were made for special downstream drainage features. Here, a horizontal pervious blanket was provided above the foundation clay. This is intercepted by a drain near the downstream toe.

Settlement Observations

Laboratory tests and analyses indicated that the foundation settlement would proceed at approximately the same rate as that of construction, and that the strength of the clay layer under these conditions would provide an adequate factor of safety with respect to stability. In order to check the validity of these assumptions, eight settlement plates were installed in the flood plain foundation. Additional plates were installed in the foundation of the east abutment, and in the embankment but their action was not significant and will not be described in this paper.

The plates were constructed of 3/8 inch metal and were two feet in diameter. As the fill was brought up, accurately measured lengths of 1" pipe, protected by 2" pipe, were coupled to a floor flange provided on the plate and to each other. The elevation of the plate at a given time was computed by subtracting the measured length of the pipe from the observed elevation of its upper extremity.

Figure 2 shows the location of these plates. The first construction stage began in September 1947 and was completed about September 1948. It will be noted that plates 1 through 4 were located near the toe of the slope during this period and consequently received little surcharge. The second stage began July 1950 and was completed about November of that year. Observations were made periodically during this time.

The riser on plate 4 was damaged in the early stages of construction. The action of the remainder is shown in figures 3 and 4. The pattern of all is similar. The observations confirmed predictions with respect to both rate and magnitude of settlement.

Seepage Observations

As previously stated, the permeability characteristics of the foundation are erratic, particularly in the flood plain area. The embankment materials, also are not uniform. In order to check the design assumptions and to obtain information concerning the composition of the dam as constructed, some 60 stand-pipe piezometers were installed. These are galvanized pipe inserted in a 5 inch diameter hole drilled into the earth. The lower 5' is backfilled with a pervious filter. The remaining length is backfilled with impervious material. Measurements are made by electrical methods.

The reservoir began filling in December 1951. The minimum power pool elevation of 310 was reached in April 1952. This elevation was substantially maintained until March 1953. The maximum power pool elevation of 330 was substantially maintained during the period 18 March - 17 April. The piezometers were installed in the spring of 1952 and have been observed periodically since that time.

In the abutment areas, the observations indicate nothing of particular interest. Here, the embankments are relatively low and are subjected to correspondingly low hydrostatic heads. The behavior of the maximum sections overlying the flood plain has been selected for discussion.

Figure 5 shows the line of standpipe heights along the rock line at the junction of the concrete and earth sections. This indicates that the cut-off measures are operating effectively. The fact that the line is brought up to the intersection of the water surface and the dam may be misleading. This portion of the line is probably much flatter than shown on the drawing, intersecting the water surface further upstream. These remarks also apply to the founda-

tion portion of the other sections which will be presented.

The situation at the east abutment just above its junction with the flood plain is shown in figure 5. Again, there is a satisfactory drop in head along the rock line. The embankment piezometers were not completely stabilized at the time shown. Subsequent observations indicate stabilization has occurred at elevations from one to three feet higher than that shown. Attention is invited to the fact that the embankment piezometers indicate the hydrostatic pressure at their tips. Since equipotential lines are somewhat curved the saturation line should be slightly higher than the dotted line shown. Embankment piezometer P-45, about 200 feet from the centerline was damaged and readings cannot be observed at this point. However, the absence of seepage above the downstream toe indicates that the saturation line remains within the embankment.

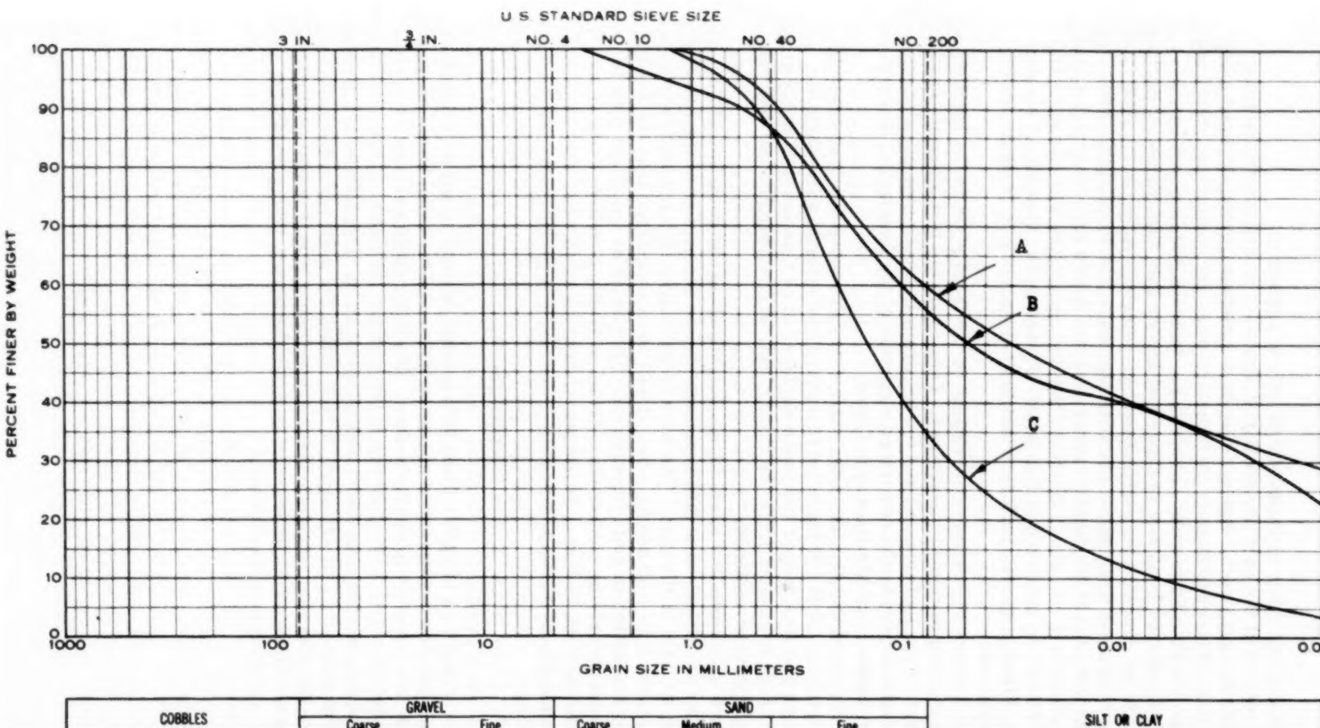
Figure 7 shows results of observations in the flood plain at the location of the filled channel previously described. These indicate that adequate head loss occurs in the embankment and the toe drain is functioning effectively. The hydrostatic head in the downstream portion of the foundation, however is somewhat higher than had been anticipated.

It will be noted that the toe of the main dam intersects the switchyard fill at elevation 240. This fill has a level surface and extends some distance downstream and then slopes to ground surface. It is composed of sandy silts and silty sands excavated from the flood plain. A considerable portion was placed by hydraulic methods.

Figure 8 shows the line of standpipe heights along the rock line at the downstream toe of the main dam superimposed on the profile of the foundation along the axis of the dam. The area of relatively high pressures lies between stations 49 + 00 and 51 + 50. It will be remembered that the top 20 feet of the foundation is quite impervious. This artesian condition may be caused by an underlying continuous stratum of highly pervious soils or by fissures in the rock or both. No abnormal seepage conditions may be observed at the toe of the switchyard fill.

Conclusion

The foregoing is a very brief and abbreviated account of investigations in connection with the performance characteristics of Clark Hill Dam. Much of the testing and analysis is yet to be done. The information obtained to date indicates that the dam is functioning in the manner intended. It has also shown the desirability of obtaining additional information in a specific area. In addition to providing positive information concerning the safety of a particular structure, investigations such as these are valuable in that actual performance may be correlated with theoretical considerations, thus providing a basis for more economical design.



Sample No.	~~Elev or Depth~~	Classification	NatWC	LL	PL	PI	
A		ML - sandy silt	21	38	32	6	Micaceous
B		CL - sandy clay	23	48	27	21	"
C		SM - silty sand	10			NP	"

Project CLARK HILL DAM

TYPICAL EMBANKMENT SOILS Fig.-1

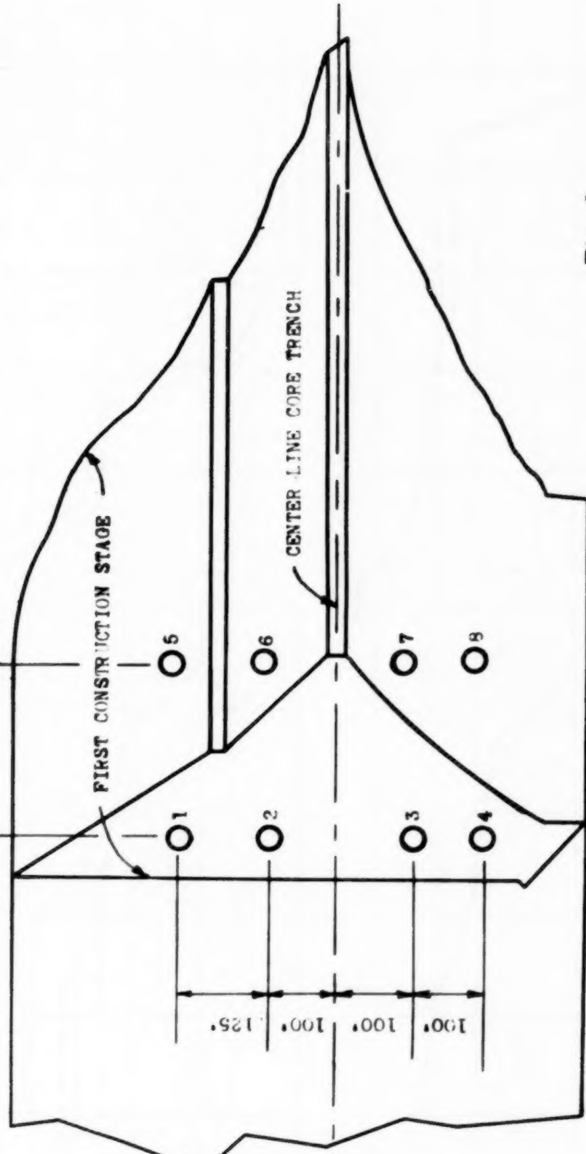
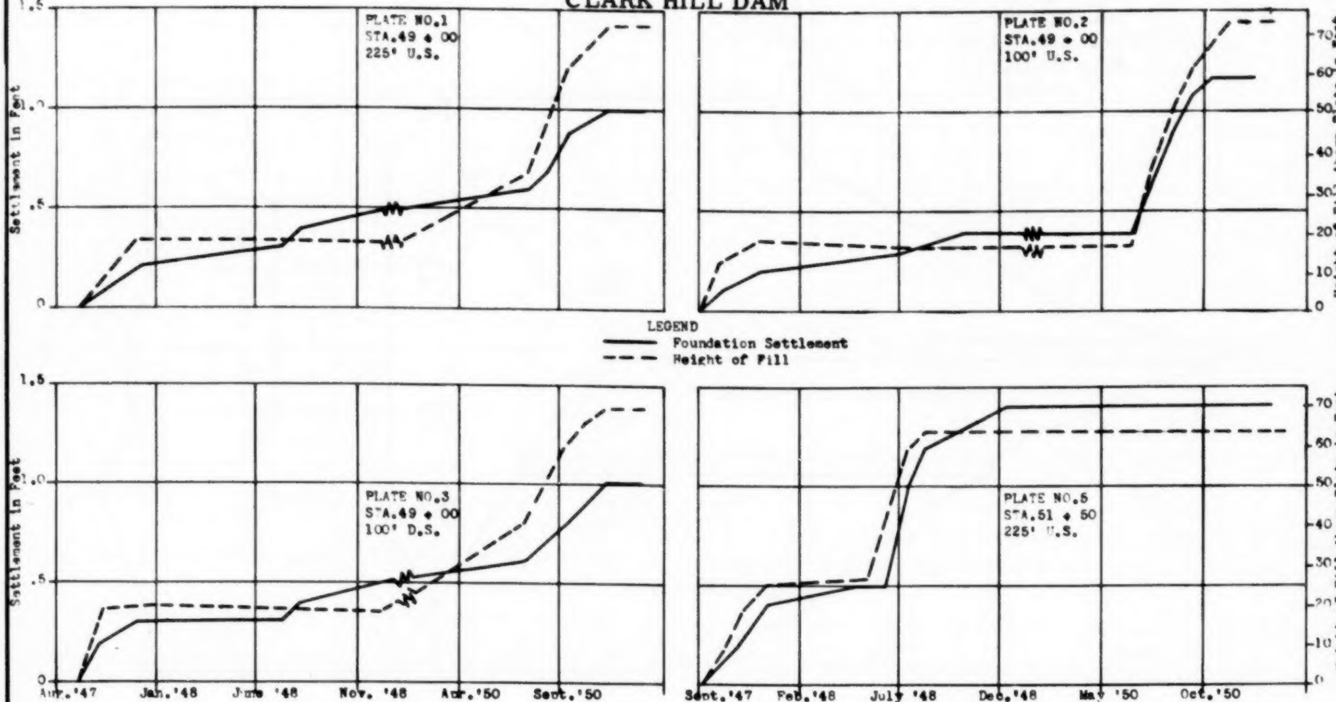


Fig.-2
LOCATION PLAN
SETTLEMENT PLATES
CLARK HILL DAM
Scale: 1" = 200'

Fig. 3-FOUNDATION SETTLEMENT
CLARK HILL DAM



FOUNDATION SETTLEMENT
CLARK HILL DAM

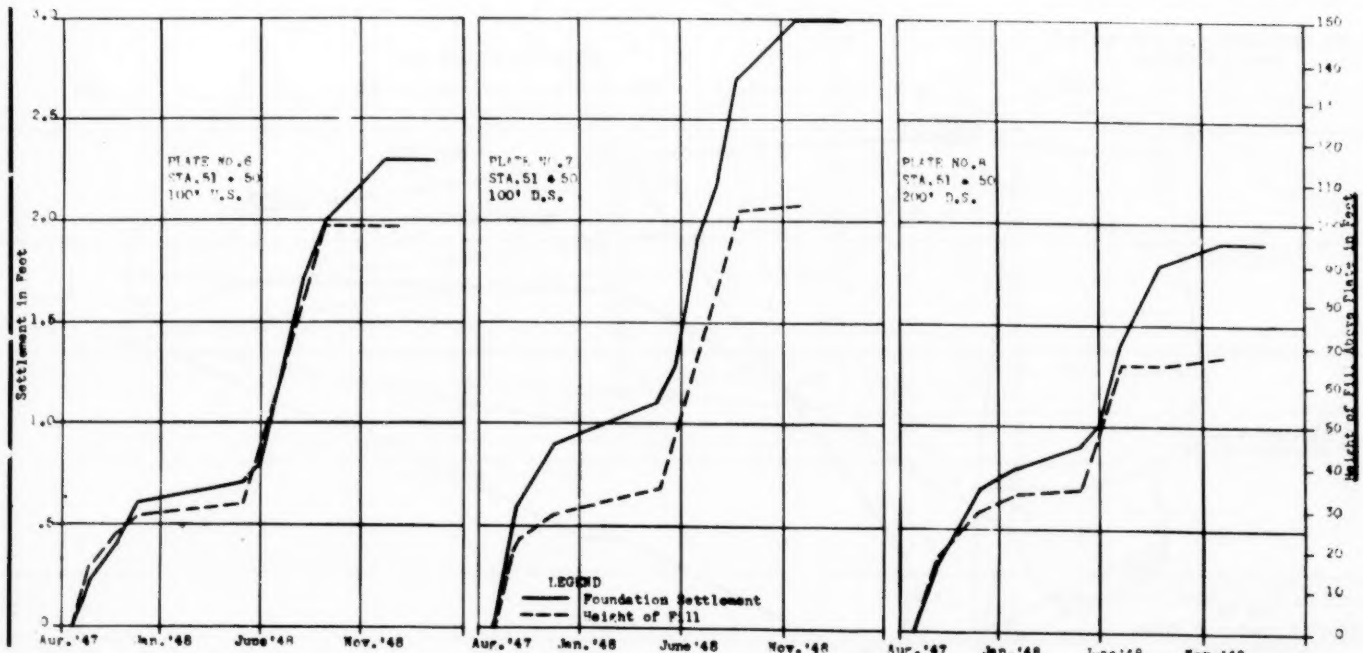
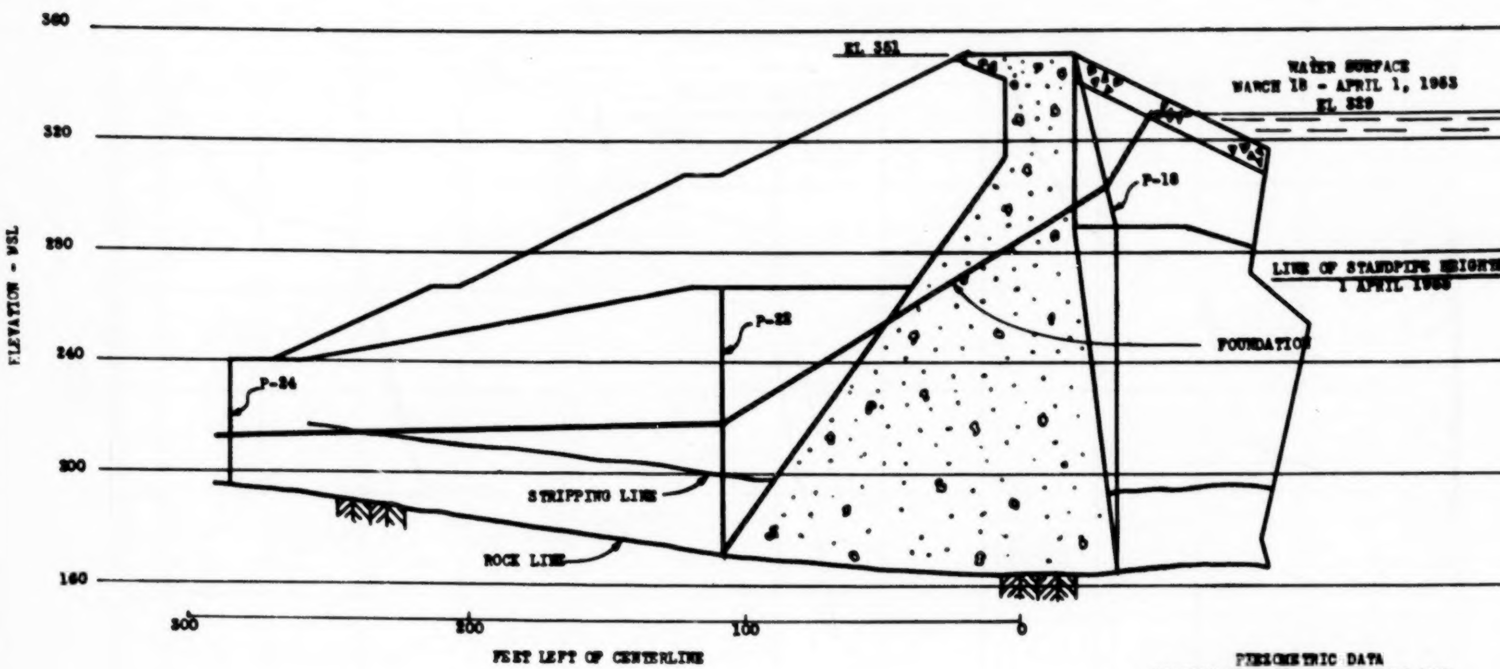
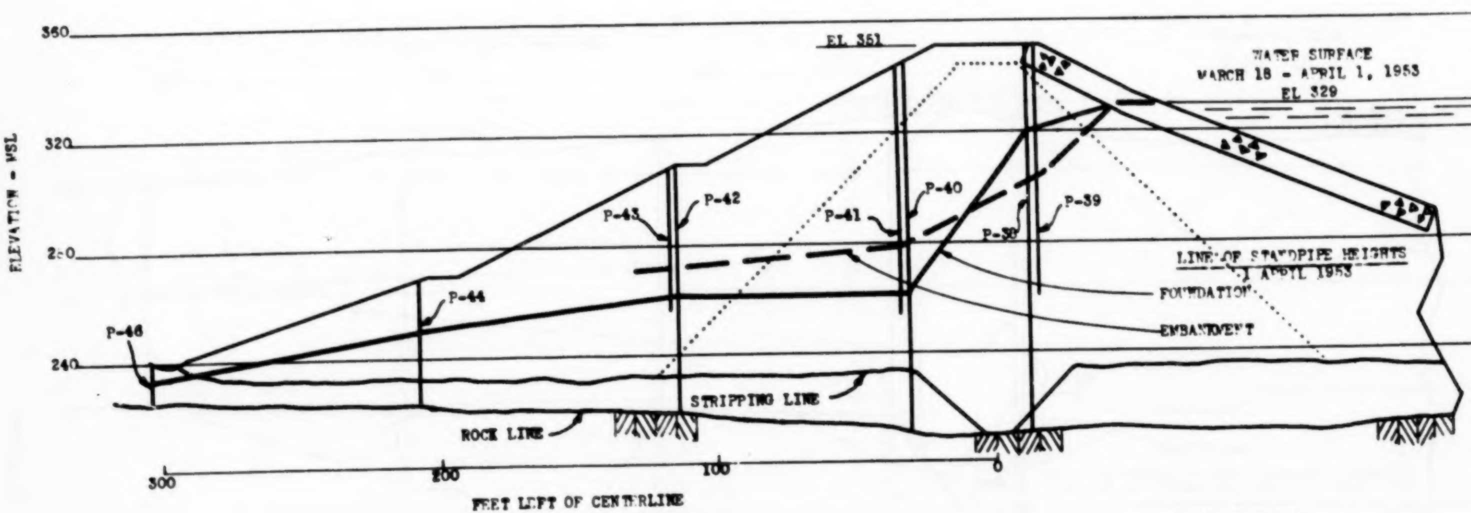


FIG.-4



PIEZOMETRIC DATA
STATION 45 + 90 - CLARK HILL DAM

FIG.-5



PIEZOMETRIC DATA
STATION 54 + 00 - CLARK HILL DAM

FIG.-6

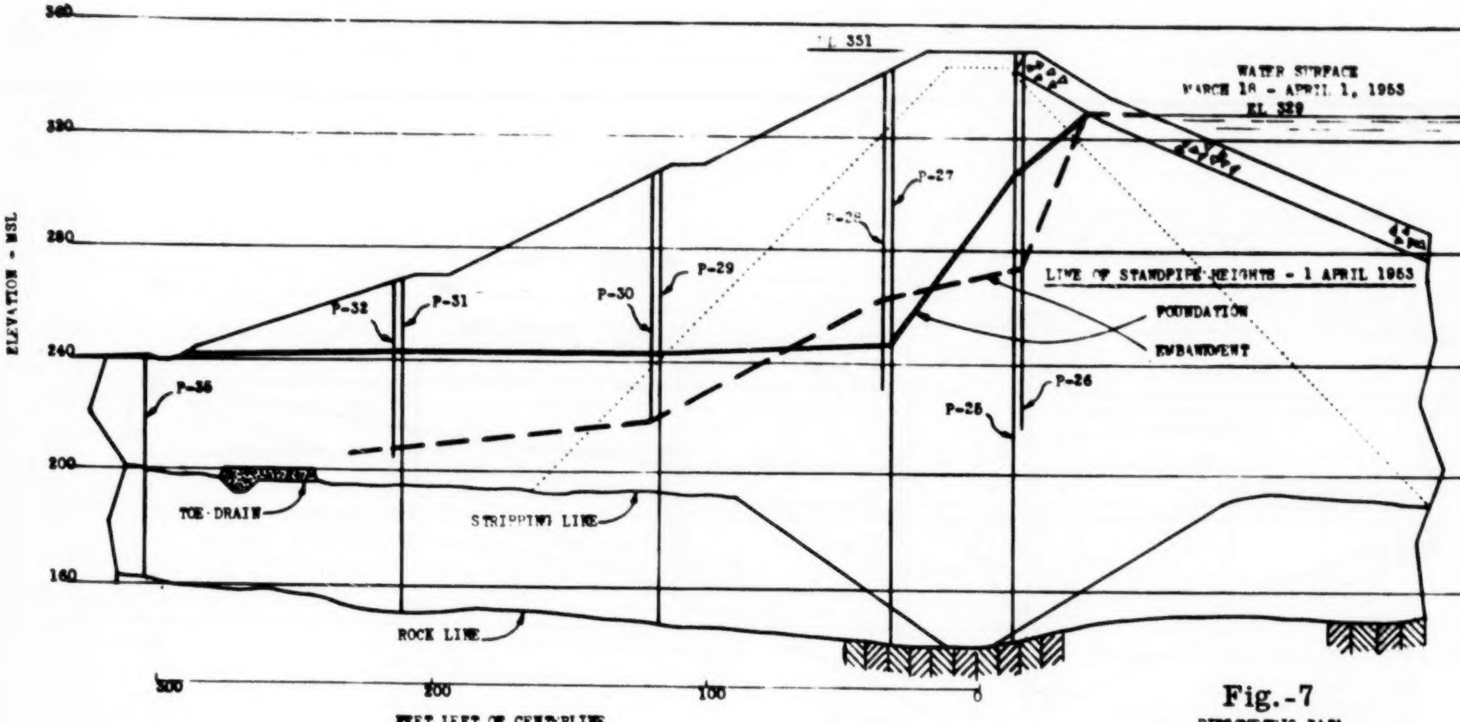


Fig.-7
PIEZOMETRIC DATA
STATION 51 + 50 - CLARK HILL DAM

FIG.- 7

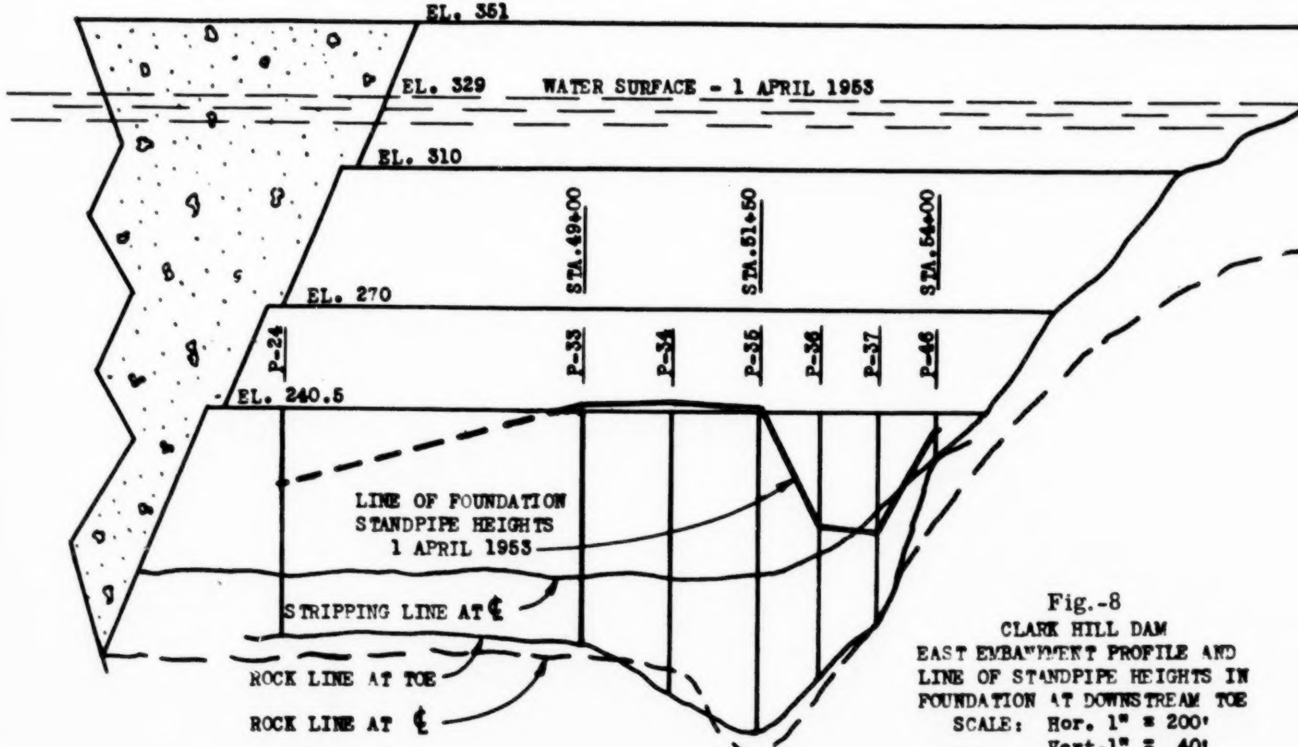


Fig.-8
CLARK HILL DAM
EAST EMBANKMENT PROFILE AND
LINE OF STANDPIPE HEIGHTS IN
FOUNDATION AT DOWNSTREAM TOE
SCALE: Hor. 1" = 200'
Vert. 1" = 40'

FIG.-8

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